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Evaluation and Popularization of Saihanba Ecological Protection

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Abstract

Ecological civilization is the historical trend of the development of human civilization. The construction history of Saihanba forest farm is even more an epic history of hard struggle. Several generations have cast the Saihanba spirit of keeping the mission firmly in mind, hard work and green development with practical actions. It not only has important practical significance for firmly establishing ecological values and new development concepts in the new era, but also creates a model in the construction history of world ecological civilization. For question 1, in order to compare and analyze the environmental conditions before and after the restoration of Saihanba, we collected the relevant data of Saihanba forest farm from 1962 to 2021, took 1983 as the division time point of the restoration, took 9 data such as forest coverage (%) as the analysis index, and established the evaluation model by using the rank sum ratio evaluation method to evaluate the ecological environment before and after the restoration. For question 2, we select 28 indicators such as disaster population from seven aspects: disaster impact, traffic impact, power impact, communication impact, agriculture, animal husbandry and industry, and build an evaluation model of Beijing's ability to resist sandstorm based on grey fuzzy comprehensive evaluation to quantitatively evaluate the role of Saihan dam in Beijing's resistance to sandstorm. For question 3, we choose the remote sensing ecological index model method (RESI) to analyze the quality of the ecological environment of Saihan dam, and use the ecological model suitable for the restoration of Saihan dam to evaluate the ecological situation of other areas. Considering the complexity of local conditions in the promotion and implementation, we select terrain and soil factors, climate and vegetation factors, human activity factors and model structure factors to build the model, and judge whether the ecological area is constructed or not based on the city. For question 4, in order to promote the Saihan dam model worldwide, we selected the United States as the research object. Firstly, a regional classification model of the United States based on K-means clustering is established. The 51 states are clustered and classified to obtain the states that need to build ecological protection areas most, and the number and scale of ecological protection areas are determined through targeted analysis; Then we collect the ecological protection data of the selected areas in previous years, and establish an ecological protection area based on DEA to evaluate its greenhouse gas absorption and carbon emission efficiency. Finally, according to the models and analysis results established in the first four questions, and comprehensively considering various factors, we put forward some feasible plans and suggestions for the construction of ecological reserves, in order to provide some reference value for the development of ecological environment in China and even the world.

Keywords

Saihanba; Ecological Protection; RESI; K-means Clustering; DEA.

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1. Introduction

1.1. Problem Background

Ecological civilization is a major achievement of human social progress. And the construction of ecological civilization is to build a civilized society with productive development, an affluent life and a sound ecological environment on the basis of the carrying capacity of resources, in accordance with the laws of nature, and with sustainable development and harmony between man and nature as our goal.

Saihanba is located in the northern part of Hebei Province. Since 1863, the forest vegetation there has been seriously destroyed, and then suffered from the Japanese invaders' plunder and cutting. In 1962, in order to "build a small and medium-sized timber forest base in North China; Change the local natural appearance, preserve soil and water, and create conditions for changing the hazards of sandstorms in The Beijing-Tianjin area; To study and accumulate experience in afforestation and afforestation in alpine areas." The former forestry department decided to establish saihanba machinery forest farm directly under this wasteland.

Thus, a group of young people with an average age of less than 24 came to Saihanba, and began decades of artificial forestation. Through the efforts of several generations of Saihanba people, the former vast wasteland has become today's vast oasis.

The people of Saihanba now have a higher goal: to restore the ecology. They have launched three major projects of afforestation, natural improvement of artificial forests and near-natural cultivation of natural forests in an attempt to make artificial forests closer to natural forests.

1.2. Our Work

According to the problem, we are required to develop appropriate models to solve the following problems:

- The ecological environment assessment model of Saihan dam is established to compare and analyze the environmental conditions before and after restoration.
- Quantitatively evaluate the impact of Saihan dam on the ability of anti sandstorm in Beijing.
- Determine which locations in China can be promoted to build ecological zones, and assess their impact on achieving China's carbon neutrality goal.
- Select another country, establish a model, discuss which locations in the country need to establish ecological zones, determine the number and scale, and evaluate its impact on reducing carbon emissions.
- Describe the established model, and put forward feasible plans and suggestions for the construction of ecological reserves

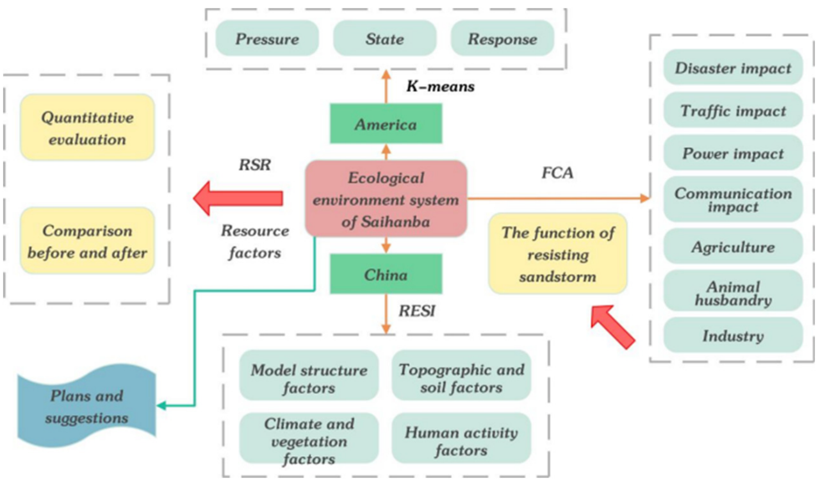

Figure 1. Flow chart of the research process

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2. Assumptions and Justifications

- The restoration period of Saihan dam began in 1983;
- The development from the current state to the proposed state is stable, and the sudden change may be ignored because it is rare;
- Exclude the influence of uncontrollable factors on the data, such as drought, flood, etc;
- Countries will actively improve the ecological environment and take appropriate measures, which is based on the response of most countries.

3. Notations

Table 1. Symbols and definition

Symbols	Definition
SSE	Clustering of deviation
LST	The surface temperature
VI	Vegetation index
NDVI	Normalized vegetation index
NDBSI	Dryness index
IBI	Building index
SI	Index of the soil
Wet	Humidity index
MNDWI	Normalized differential water index

4. Models and Solutions

4.1. Evaluation of the Impact of Saihanba on Ecological Environment

4.1.1. Problem Analysis

In order to make a comparative analysis of the environmental conditions before and after the restoration of Saihanba, we collected relevant data of Saihanba Forest Farm from 1962 to 2021, and took 1983 as the time point of division, namely 1962-1982 as the pre-restoration period and 1983-2021 as the post-restoration period. Nine data, including forest coverage rate (%), were used as analysis indicators. The rank sum ratio evaluation method was used to establish the evaluation model, and the comparison results were obtained.

4.1.2. RSR Model

This paper uses the forest coverage rate (%), cover area (ten thousand acres), trees (cubic meters), water conservation (millions of cubic meters), carbon dioxide absorption (ten thousand tons), oxygen release quantity (ten thousand tons), land degradation index and pollution load index and the bad weather accounted for the analysis of the problem than as a study.

Where, land degradation index =Aero×(0.05×mild erosion area +0.25×moderate erosion area +0.7×severe erosion area)/ area,Aero is the normalized coefficient of land degradation index; Pollution load index =(ASO2×0.4×SO2 emissions +Asol×0.2× solid waste emissions)/ area +ACOD×0.4×COD emissions/ average annual rainfall, ASO2 is the normalization coefficient of SO2, Asol is the normalization coefficient of solid waste, and ACOD is the normalization coefficient of COD.

Obviously, among the 9 indicators mentioned above, the first 6 indicators are benefit indicators, and the larger the value is, the more beneficial it is. The last three indicators are cost indicators, and the smaller the value, the more beneficial. The data plots of the two indicators can be obtained as follows:

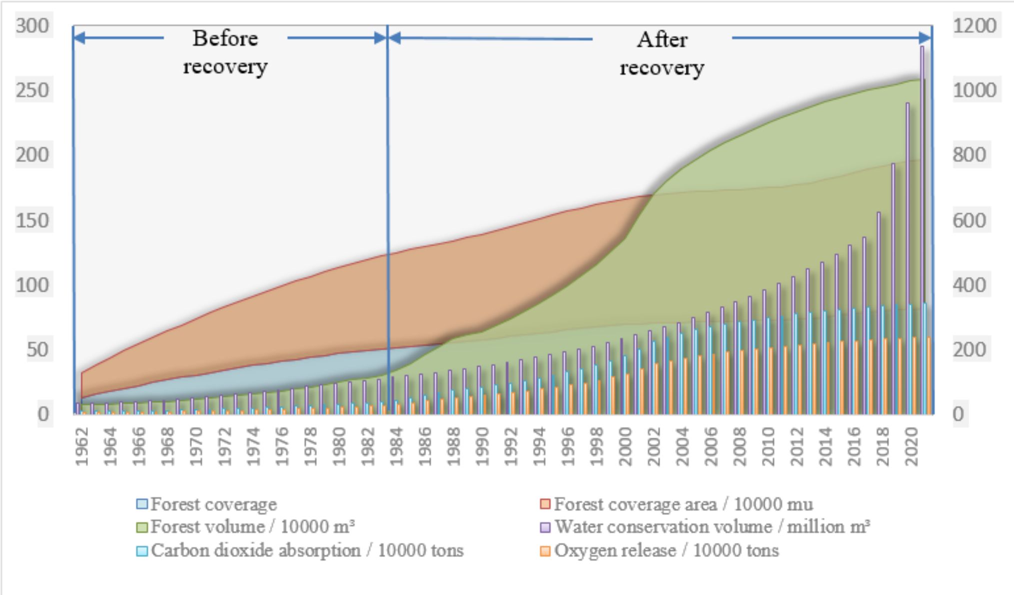

Figure 2. Benefit indicator trend chart

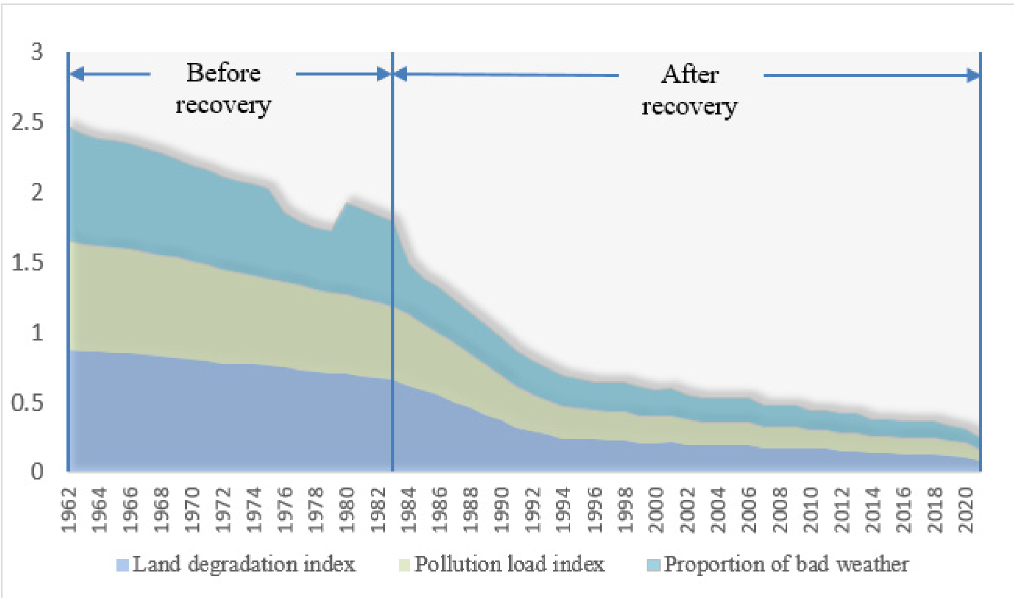

Figure 3. Cost indicator trend chart

It can be seen from Figure.2 and 3 that the values of the six benefit indicators increased with the increase of years, especially after 1983. The values of the three cost indicators also decreased with the increase of years, especially after 1983. From this point of view, the restoration of Saihanba has a positive effect on the environment that cannot be ignored.

Then, we averaged the index values from 1962-1982 and 1983-2021 respectively as the evaluation data. In order to overcome the disadvantage of easy loss of quantitative information of original index values in RSR rank ranking, we used the non-integral rank method for rank ranking, and assigned values by entropy weight method. The number of evaluation files was divided into three grades, and the higher the grade, the better the effect. Then, the software was used for comprehensive rank sum ratio evaluation. The RSR distribution table can be obtained as follows:

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Table 2. RSR distribution

RSR	Frequency *f*	Cumulative FrequencyΣf	Evaluation rank number	Evaluation rank number /n*100%	Probit
0.358	1.000	1.000	1.000	49.000	3.790
1.000	1.000	2.000	2.000	87.500	6.150

According to the results of RSR, we calculated the critical values of the three grades respectively, and the results are shown in Table.3:

Table 3. The table of threshold values for the classification sort

Grade	Percentile threshold	Probit	RSR critical value (fit value)
Grade 1	<15.866	<4	<0.0654
Grade 2	15.866 ~	4 ~	0.0654 ~
Grade 3	84.134 ~	6 ~	0.9346 ~

4.1.3. Results

According to the classification basis obtained in Table.3, we can make a file evaluation of the environmental status of Saihanba before restoration (962-1982) and after restoration (1983-2021), and the results are shown in Table.4:

Table 4. Summary of grade results

Recovery phase	RSR_Rank	Probit	RSR Regression	Level
Before the recovery (In 1983-2021)	1.000	6.150	1.000	3
After the recovery (In 1962-1982)	2.000	3.790	0.358	1

According to the results in Table.4, the larger the number of grade Level is, the higher the Level is, namely, the better the effect is. The grade of the pre-restoration stage (1983-2021) is 3, and the grade of the post-restoration stage (1983-2021) is 1, indicating that the environmental status of Saihanba Forest farm in the post-restoration stage is significantly better than that in the pre-restoration stage.

In order to more intuitively represent the changes of environmental conditions in Saihanba Forest farm, we took Forest coverage area / 10000 mu and Water conservation volume/million m^3 as examples to draw contour maps. To reflect the intensity and distribution of data, as shown in Figure.4.

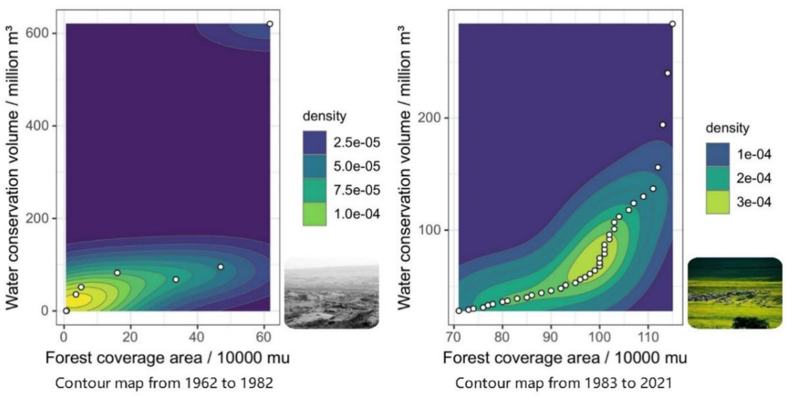

Figure 4. Contour map of Saihanba before and after restoration

In Figure.4, the left is the pre-restoration stage, and the right is the post-restoration stage. It can be clearly seen from the distribution of data points and coordinate axis values in the figure that the density of Forest Coverage area and water conservation volume in Saihanba increases significantly after the restoration, and the data distribution is more extensive. In addition, we attach a picture of Saihanba in the current period to the left and right, according to which we can judge that the restoration of Saihanba has expanded vegetation coverage, enriched water resources and oxygen content, reduced land degradation and pollution load, and had a huge positive impact on the ecological environment.

4.2. Effect of Saihanba on Anti - sand in Beijing

4.2.1. Problem Analysis

4.2.2. Grey Fuzzy Comprehensive Evaluation Model

a. Index selection

By referring to The Statistical Yearbook of Beijing and related websites and integrating previous research and analysis, we selected 28 indicators from 7 levels to construct an evaluation model of Beijing's wind-sand resistance capacity based on grey and fuzzy comprehensive evaluation. The specific indicators are shown in Figure. 5.

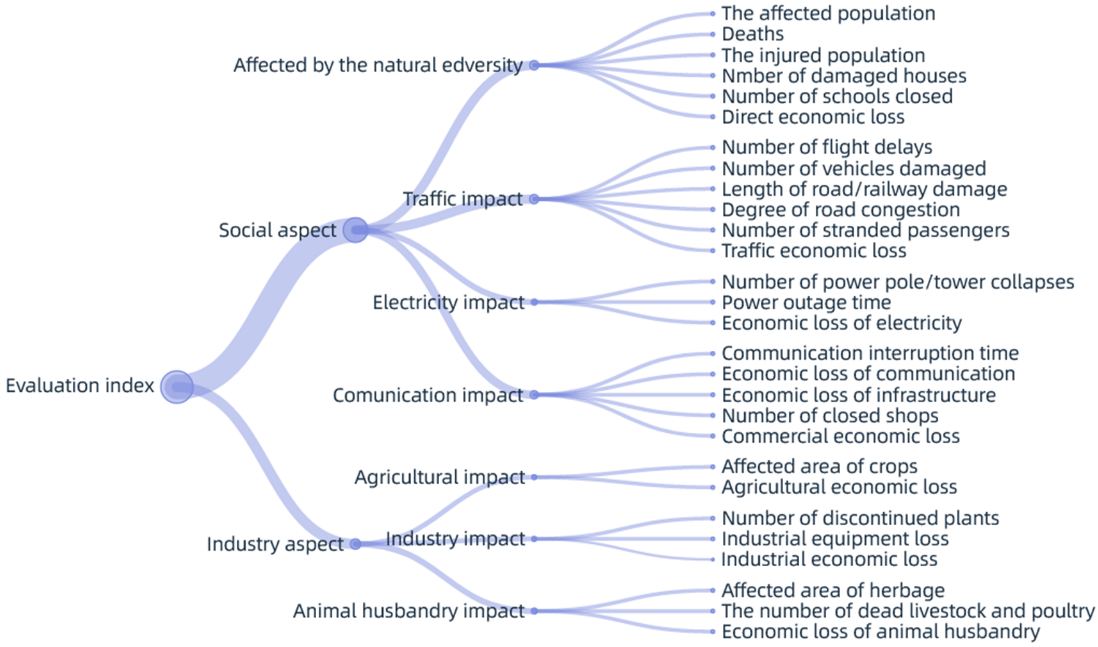

Figure 5. Detailed indicator chart

b. Determine index weight

The target layer consists of seven elements and index layer sets are as follows: $U=\{U_1,U_2,U_3,U_4,U_5,U_6,U_7\}$, $U_1=\{U_{11},U_{12},U_{13},U_{14},U_{15},U_{16}\}$, $U_2=\{U_{21},U_{22},U_{23},U_{24},U_{25},U_{26}\}$, $U_3=\{U_{31},U_{32},U_{33}\}$, $U_4=\{U_{41},U_{42},U_{43},U_{44},U_{45}\}$, $U_5=\{U_{51},U_{52}\}$, $U_6=\{U_{61},U_{62},U_{63}\}$, $U_7=\{U_{71},U_{72},U_{73}\}$.

We invite have rich experience in the field of natural ecological environment research five experts using 1 ~ 9 of each layer of index scale method with indicators to quantify the relative importance of between adjacent layers, then build interval judgment matrix, and then the single weight of 7 elements respectively and the single weight of 28 indicators, to multiply by 28 comprehensive weights of indicators. When judging the consistency of the matrix, the value of the average random consistency index RI is shown in Table.5:

Table 5. RI value table

Matrix dimension	1	2	3	4	5	6
RI	0	0	0.52	0.89	1.12	1.23

Determine the index weight of factor layer. A judgment matrix is constructed for the seven factors including the impact of disaster, traffic, electricity, communication, agriculture, industry and animal husbandry in the evaluation system of Beijing's ability to resist sandstorm. It can be obtained through the factor judgment matrix $W = (0.237, 0.169, 0.233, 0.196, 0.065, 0.051, 0.049)$, through consistency test, the maximum characteristic root is $\lambda_{\max} = 5.17$, $CI/RI = 0.051 < 0.1$, through the consistency test, the weight of each index at the element level is shown in Figure. 6.

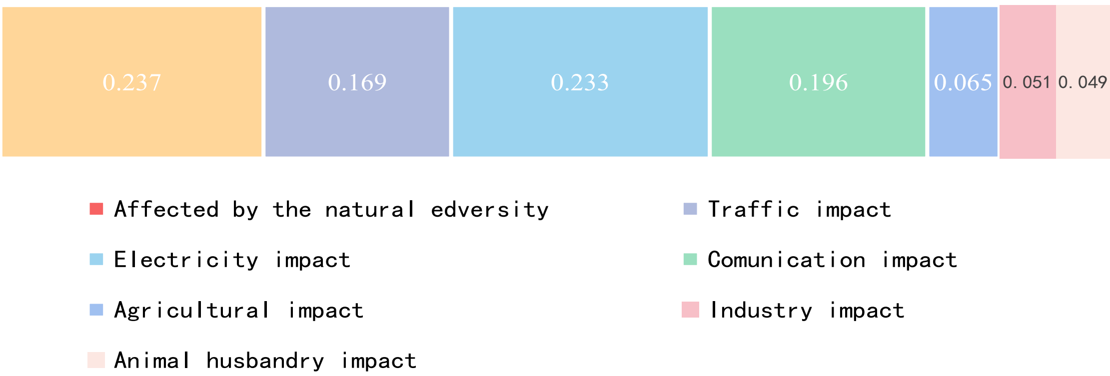

Figure 6. The weight of the element layer

Determine the index weight of the index layer. The internal factors of each factor layer index are compared in pairs one by one to determine the judgment matrix of each index. According to the judgment matrix, the corresponding weight is determined to obtain the weight of each index in the evaluation of Beijing's ability to resist sandstorm, as shown in Table 6.

Table 6. Weight of Beijing's ability to resist sandstorm

Elements layer	Single weight	Index layer	Single weight	Comprehensive weight
Affected by the natural edversity	0.237	The affected population	0.207	0.049
		Deaths	0.234	0.055
		The injured population	0.145	0.034
		Number of damaged houses	0.137	0.032
		Number of schools closed	0.107	0.025
		Direct economic loss	0.170	0.040
Traffic impact	0.169	Number of flight delays	0.099	0.017
		Number of vehicles damaged	0.166	0.028
		Length of road/railway damage	0.237	0.040
		Degree of road congestion	0.211	0.036
		Number of stranded passengers	0.181	0.031
		Traffic economic loss	0.106	0.018

Elements layer	Single weight	Index layer	Single weight	Comprehensive weight
Electricity impact	0.233	Number of power pole/ tower collapses	0.428	0.100
		Power outage time	0.211	0.049
		Economic loss of electricity	0.361	0.084
Communication impact	0.196	Communication interruption time	0.270	0.053
		Economic loss of communication	0.230	0.045
		Economic loss of infrastructure	0.164	0.032
		Number of closed shops	0.121	0.024
		Commercial economic loss	0.215	0.042
Agriculture impact	0.065	Affected area of crops	0.666	0.043
		Agricultural economic loss	0.434	0.028
Industry impact	0.051	Number of discontinued plants	0.179	0.009
		Industrial equipment loss	0.268	0.014
		Industrial economic loss	0.553	0.028
Animal husbandry impact	0.049	Affected area of herbage	0.471	0.023
		The number of dead livestock and poultry	0.336	0.016
		Economic loss of animal husbandry	0.193	0.009

c. Determine the evaluation criteria and evaluation sample matrix

Evaluation criteria. The evaluation standard is a set of possible evaluation results of the evaluation object (factor index), usually represented by capital letter V. In the assessment of Beijing's ability to withstand sandstorms, the final assessment result is on a 10-point scale, with "excellent", "good", "medium" and "poor" corresponding to "9", "7", "5" and "3" respectively.

Evaluation sample matrix. The serial number of experts in sand storm resistance assessment of Beijing is (p= 1,2... , k), p is the number of experts, p =5 in this paper. According to the expert scoring, the score $d_{ijk}\left(i=1,2,3,4,5; j=1,2,3,4,5; k=1,2,3,4,5\right)$ is obtained by the Kth expert scoring index U_{ij}. The scoring range of each index is [0,10]. The higher the score is, the higher the grade is, the better of the effect is.

d. Determine the grey class and whitening weight functions

The grey class in grey theory quantifies its qualitative range into specific value through a function relation, which is called whitening weight function of grey number, and this specific value is the whitening value of grey number. Green building development level evaluation results for {excellent, good, middle, bad}, the corresponding score is {9,7,5,3}, so the corresponding set for evaluation of grey class rank 4, e = (1, 2, 3, 4), namely the whitenization weight function of the turning point in 9, 7, 5, 3, whitenization weight function respectively according to the upper level, middle level and lower level Settings, The whitening weight function of this model is established as follows:

When e=1, the first grey class is "excellent" and the grey number $\otimes_1 \in \left[9, \infty\right)$ is set, The whitening weight function is:

$$f_1\left(d_{ijk}\right)=\begin{cases} d_{ijk}/9 & d_{ijk}\in[0,9) \\ 1 & d_{ijk}\in(9,\infty) \\ 0 & Others \end{cases}$$

When e=2, the second grey class is "good" and the grey number $\otimes_2 \in [0,7,14]$ is set, The whitening weight function is:

$$f_2\left(d_{ijk}\right)=\begin{cases} d_{ijk}/7 & d_{ijk}\in[0,7] \\ \left(14\text{-d}_{ijk}\right)/7 & d_{ijk}\in(7,14] \\ 0 & Others \end{cases}$$

When e=3, the 3th grey class is "middle" and the grey number $\otimes_3 \in [0,5,10]$ is set, The whitening weight function is:

$$f_3\left(d_{ijk}\right)=\begin{cases} d_{ijk}/5 & d_{ijk}\in[0,5] \\ \left(10\text{-d}_{ijk}\right)/5 & d_{ijk}\in(5,10] \\ 0 & Others \end{cases}$$

When e=4, the 4th grey class is "bad" and the grey number $\otimes_4 \in [0,3,6]$ is set, The whitening weight function is:

$$f_4\left(d_{ijk}\right)=\begin{cases} 1 & d_{ijk}\in[0,3] \\ \left(6\text{-d}_{ijk}\right)/3 & d_{ijk}\in(3,6] \\ 0 & Others \end{cases}$$

e. Grey evaluation coefficient and grey evaluation matrix calculation

The grey evaluation coefficient x_{ij} of each evaluation index is the sum of the grey evaluation coefficient of each evaluation index belonging to each grey category, and the grey evaluation coefficient of each evaluation index belonging to each grey category is the sum of the calculated values of each expert's score under the whitening weight function, and the calculation formula is as follows:

$$x_{ij}=\sum_{e=1}^{4}\left(x_{ije}\right)$$

$$x_{ije}=\sum_{k=1}^{5} f_e\left(d_{ijk}\right)$$

The fuzzy evaluation weight r_{ije} of each index in the evaluation model belonging to the e grey class should be calculated separately, is the ratio of the grey evaluation coefficient of each evaluation index belonging to each grey category to the grey evaluation coefficient of each index, and the calculation formula is:

$$r_{ije}=\frac{x_{ije}}{x_{ij}}$$

According to the fuzzy evaluation weight, the whitening weight vector of the corresponding index is obtained: $r_{ij}=\left(r_{ij1},r_{ij2},r_{ij3},r_{ij4}\right)$, Thus, the grey evaluation weight matrix of index U_{ij}

belonging to the evaluated element U_i for each evaluation grey category is obtained: $r_i = \left[r_{i1}, r_{i2}, \cdots, r_{ij} \right]^T$.

f. Carry out comprehensive evaluation

The comprehensive evaluation of each index U_{ij} at the index layer is carried out according to the weight, and the grey evaluation vector is obtained: $b_i = W_i \times R_i = \left(b_{i1}, b_{i2}, b_{i3}, b_{i4} \right)$, From b_i, the evaluation weight matrix of the target layer to its element can be obtained: $B = \left[b_1, b_2, b_3, b_4 \right]^T$, comprehensive evaluation result of Beijing's ability to resist sandstorm is $S = W \times B = \left(B_1, B_2, B_3, B_4 \right)$.

In order to make the evaluation result more intuitive and accurate, S should be further processed to make S single value and calculate the comprehensive evaluation value of the index. Set the vector of evaluation grey class grade value as $C = (9, 7, 5, 3)$, then the comprehensive evaluation result of the evaluation of Beijing's ability to resist sandstorm is $A = S \bullet C^T$, Finally, according to the evaluation value, the evaluation conclusion is determined according to the evaluation index grade scoring interval.

4.2.3. Results

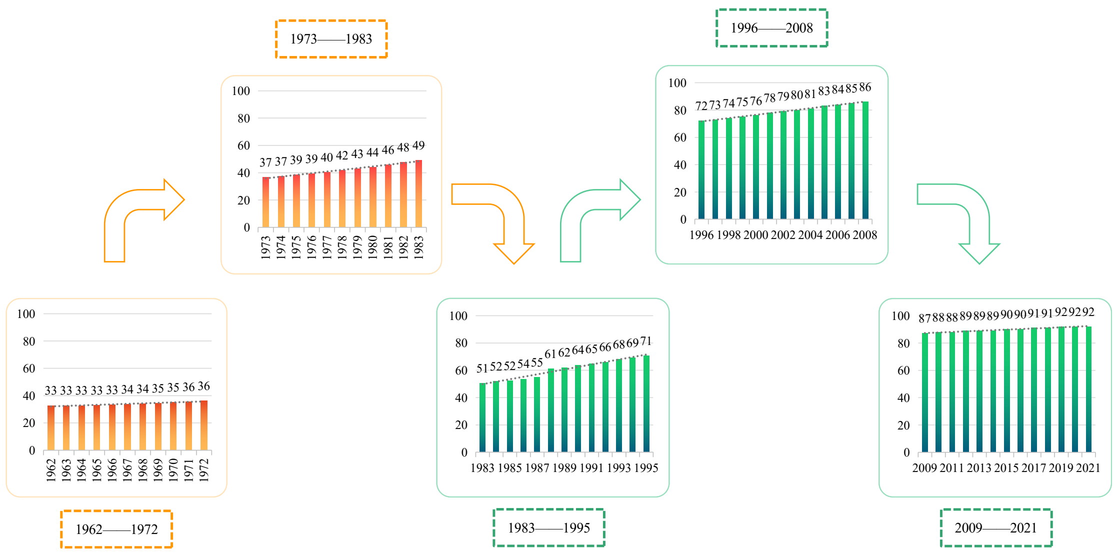

Figure 7. Change of evaluation score

It can be seen from Figure. 7 that During 1962 ~ 2021, Beijing's ability to resist sandstorms continued to increase. During 1962~1972, because Saihanba Forest Farm was just built, its forest coverage area and coverage rate were still at a low level, which failed to promote Beijing's ability to resist sandstorms. Therefore, during this period, Beijing's ability to resist sandstorms is still at a low level. From 1973 to 1983, The construction of Saihanba Forest Farm was already in the growth stage, large-scale trees had been growing, and the forest coverage area and coverage rate of Saihanba were also gradually increasing. At this time, Under the positive influence of Saihanba Forest Farm, Beijing's ability to resist sandstorms was also in the initial growth stage. From 1983 to 2008, Saihanba Forest Farm not only strengthened exploration and development and afforestation, but also paid more attention to scientific forest management, forest farm reform, national natural resource protection and ecological civilization construction of the forest farm. During this period, the forest coverage area and ecological environment level of Saihanba Forest Farm increased significantly. Under the influence of Beijing, Its ability to withstand dust storms has also risen sharply; From 2009 to 2021, as the

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ecological environment level of Saihanba Forest farm has reached a high level, its growth gradually slowed down. Similarly, the ability of Beijing to resist sandstorms also reached a stable high level.

4.3. Extending the Ecological Protection of Saihanba to the Whole Country

4.3.1. Problem Analysis

In order to promote the ecological protection mode of Saihanba, we should first understand the ecological status of the region. The suitable conditions for promotion should be that the ecological environment status of the region is similar to that before the restoration of Saihanba, and all development factors of the region can be in line with the development direction of Saihanba.

For this reason, we choose remote sensing ecological index model (RSEI) method, that is, through principal component analysis, coupled with four important ecological environmental impact factors (greenness, temperature, dryness and humidity) to analyze the ecological environment quality of Saihanba, and use the ecological model suitable for the restoration of Saihanba to consider the ecological conditions of other areas. Considering to promote implementation of the complexity of the situation around, on the basis of index of the first question, we joined the social factors and other resources, which select the terrain and soil factors, climate and vegetation factor, human activity factor and factor to build the model, model structure and the ecological construction in the city or not judgement.

4.3.2. RESI Model

a. Selection and description of indicators

For terrain and soil factors, climate and vegetation factors, human activities factors and model structure factors, we set 4 specific indicators under each factor for quantification, as shown in Figure.8:

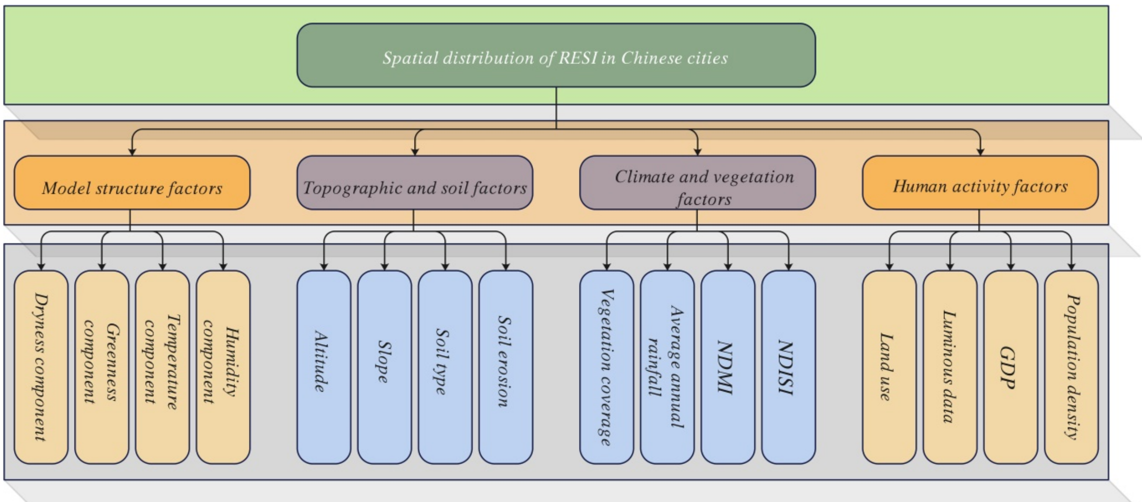

Figure 8. Relationship diagram of influencing factors of RESI spatial distribution characteristics in various cities

Greenness index: Normalized vegetation index (NDVI) is closely related to plant biomass, leaf area index and vegetation coverage. Therefore, WE choose NDVI to represent greenness component;

Temperature index: Inversion of surface temperature by radiative transfer method:

$$L_{10}=\tau_{10}\left[\varepsilon b_{10}(T_s)+(1-\varepsilon_{10})I_{10}\downarrow\right]+I_{10}\uparrow$$

$$T_s=k_2\Big/\ln\left(\frac{k_1}{L_{10}}+1\right)$$

Among them, L_{10} is the radiation brightness value at the sensor; b_{10} is the transmittance of the atmosphere in the thermal infrared band 10; ε is the surface specific emissivity; $I_{10}\uparrow$ is the atmospheric upward radiation brightness; $I_{10}\downarrow$ is the brightness of descending atmospheric radiation; $b_{10}(T_s)$ is the radiation brightness of the same black body as T_s, which can be calculated by Planck's formula; k_1 and k_2 are the scaling parameters.

Dryness index: Since both building land and bare soil are representative elements of surface "drying", dryness index (NDBSI) is formed by coupling building index IBI and soil index SI. Where, ρ_i represents the reflectivity of each corresponding band of OLI image.

$$NDBSI=(SI+IBI)/2$$

$$SI=\frac{(\rho_{SWIR_1}+\rho_{RED})-(\rho_{BLUE}+\rho_{NIR})}{(\rho_{SWIR_1}+\rho_{RED})+(\rho_{BLUE}+\rho_{NIR})}$$

$$IBI=\frac{\frac{2\rho_{SWIR_1}}{\rho_{SWIR_1}+\rho_{NIR}}-\left(\frac{\rho_{NIR}}{\rho_{NIR}+\rho_{RED}}+\frac{\rho_{GREEN}}{\rho_{GREEN}+\rho_{SWIR_1}}\right)}{\frac{2\rho_{SWIR_1}}{\rho_{SWIR_1}+\rho_{NIR}}+\left(\frac{\rho_{NIR}}{\rho_{NIR}+\rho_{RED}}+\frac{\rho_{GREEN}}{\rho_{GREEN}+\rho_{SWIR_1}}\right)}$$

Humidity index: The Tasseled Cap transformation is widely applied in ecological environment research, and its brightness, greenness and humidity components are directly related to surface physical parameters. Therefore, the humidity component Wet of spike cap transformation is selected as humidity index, and ρ_i also represents the reflectivity of each corresponding band of OLI image.

Soil erosion: The universal soil loss equation (USLE) is widely used in quantitative evaluation of soil erosion intensity, rational utilization of land resources and water and soil conservation planning. USLE model was selected to simulate soil erosion in the study area.

$$A=R\cdot K\cdot LS\cdot C\cdot P$$

Where, A is the average annual soil loss per unit area (T •hm-2•a-1); R is rainfall erosivity factor; K is soil erodibility factor; LS is slope length slope factor; C is vegetation cover and crop management factor; P is soil and water conservation factor.

Acquirement of NDMI and NDISI:

$$NDMI=\frac{\rho_{NIR}-\rho_{MIR_1}}{\rho_{NIR}+\rho_{MIR_1}}$$

$$NDISI=\frac{\rho_{TIR}-(MNDWI+\rho_{NIR}+\rho_{MIR_1})/3}{\rho_{TIR}+(MNDWI+\rho_{NIR}+\rho_{MIR_1})/3}$$

$$MNDWI=\frac{\rho_{GREEN}-\rho_{MIR_1}}{\rho_{GREEN}+\rho_{MIR_1}}$$

Where, MNDWI is the normalized differential water index.

b. Establishment and analysis of RESI model

The four eco-environmental impact factors (greenness, temperature, dryness and humidity) could be indicated and expressed by vegetation index (VI), surface temperature (LST), bare soil and vegetation index (NDBSI) and the humidity component of spike cap transformation, respectively. Based on RESI model results, this paper represents the ecological environment quality of each region, and its expression is as follows:

$$RESI = f(VI, LST, NDBSI, W_{et})$$

The explanatory power of influence factor x_i on the spatial differentiation characteristics of RSEI q can be expressed as:

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{SSW}{SST}$$

$$SSW = \sum_{h=1}^{L} N_h \sigma_h^2 \ , \ SST = N\sigma^2$$

Where, L is the number of layers of independent variable x_i; N_h and N are the sample numbers within the layer and region respectively; σ^2 is the sample population variance, when $\sigma^2 \neq 0$, Model was set up; SSW is the sum of the variances within layers; SST is the total variance of the sample; q∈[0,1], the larger the q value is, It shows that x_i has stronger explanatory power to RSEI spatial differentiation.

F statistics to compare the influence of two types of factors x_1 and x_2 on the spatial distribution of RSEI are significantly different:

$$F = \frac{N_{x_1}(N_{x_2} - 1) SSW_{x_1}}{N_{x_2}(N_{x_1} - 1) SSW_{x_2}}$$

$$SSW_{x_1} = \sum_{h=1}^{L_1} N_h \sigma_h^2 \ , \ SSW_{x_2} = \sum_{h=1}^{L_2} N_h \sigma_h^2$$

In the formula, SSWX1 and SSWX2 are the sum of the intralayer variances formed by x_1 and x_2 respectively; N_{x_1} and N_{x_2} represents the sample number of two types of factors. Where H0 is assumed to be SSWX1=SSWX2, If rejecting H0 at the significance level of α, it indicated that there were significant differences in the effects of two types of factors x_1 and x_2 on the spatial distribution of RSEI. (Y represents significant difference, N represents no significant difference)

After obtaining various data, we conducted principal component analysis on the four components of RSEI model. The first principal component PC1 after principal component transformation was selected to reflect the ecological environmental quality of Saihanba and explore the influence and correlation of each indicator component on PC1. The results are shown in Table. 7.

Table 7. Influence and correlation of index components of RSEI model

Index	PC_1	The correlation coefficient R
Greenness	0.57	0.86
Dryness	-0.65	-0.97
Humidity	0.26	0.75
Temperature	-0.43	-0.76
Contribution (%)	75.05	-

As can be seen from Table. 7, the first principal component PC1 in THE RSEI model contains most of the information of the four indicators and has a good correlation with each indicator. Therefore, the first principal component PC1 in RSEI model results was selected to represent the overall eco-environmental quality of the study area.

Then, the explanatory power of 16 influencing factors on the spatial differentiation characteristics of RSEI was explored, and the results were shown in Table. 8.

Table 8. Single factor detection result

Detection factor		Explanatory power q	Significant level P	Sort (q value from high to low)
Model structure factors	Dryness component	0.7795	0	2
	Greenness component	0.6629	0	3
	Temperature component	0.4954	0	6
	Humidity component	0.5785	0	5
Topographic and soil factors	Altitude	0.0138	0	15
	Slope	0.0191	0	14
	Soil type	0.0294	0	13
	Soil erosion	0.0618	0	9
Climate and vegetation factors	Vegetation coverage	0.6302	0	4
	Average annual rainfall	0.0128	0	16
	NDMI	0.8765	0	1
	NDISI	0.0351	0	12
Human activity factors	Land use	0.3363	0	7
	Luminous data	0.0808	0	8
	GDP	0.0476	0	11
	Population density	0.0501	0	10

It can be seen from Table.8 that the P values of all detection factors are 0, indicating that the selected detection factors have a significant impact on the spatial differentiation characteristics of RSEI and can be used as influencing factors to analyze its differentiation. In addition to the strong explanatory power of model structure factors on the spatial differentiation characteristics of RSEI,NDMI and vegetation coverage q values were also high, which were the main influencing factors of RSEI spatial distribution. However, land use type has a relatively strong explanatory power and is a secondary factor (except model structure factor). The explanations of the 9 factors such as annual average rainfall, altitude and soil erosion were weak, and the q values were all less than 0.1. From the perspective of single detection factor, NDMI has the strongest explanatory power to the spatial differentiation of RSEI, even stronger than the model structure factor, with q value up to 0.8765. However, the annual mean rainfall has the weakest explanatory power to the spatial differentiation of RSEI, and the q value is 0.0128. From the perspective of detection factors, the explanatory power of RSEI spatial differentiation is in the following order: model structure factor > climate and vegetation factor > human activity factor > terrain and soil factor.

After the single-factor study, we continued to analyze the relationship between the interaction between probe factors and the spatial differentiation characteristics of RSEI. The specific results are shown in Figure. 9.

Influence factor		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
Dryness component	X1	0.779	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Greenness component	X2	0.886	0.663	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Temperature component	X3	0.819	0.826	0.495	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Humidity component	X4	0.883	0.861	0.718	0.579	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Altitude	X5	0.820	0.673	0.532	0.591	0.014	N	N	Y	Y	N	Y	N	Y	Y	Y	Y
Slope	X6	0.817	0.667	0.524	0.586	0.027	0.019	N	Y	Y	N	Y	N	Y	Y	N	N
Soil type	X7	0.824	0.678	0.538	0.596	0.046	0.048	0.029	Y	Y	N	Y	N	Y	Y	N	N
Soil erosion	X8	0.789	0.669	0.516	0.615	0.070	0.080	0.088	0.062	Y	Y	Y	N	Y	N	N	N
Vegetation coverage	X9	0.885	0.670	0.815	0.850	0.643	0.635	0.645	0.637	0.630	Y	Y	Y	Y	Y	Y	Y
Average annual rainfall	X10	0.818	0.678	0.529	0.596	0.029	0.030	0.049	0.072	0.646	0.013	Y	N	Y	Y	Y	Y
NDMI	X11	0.909	0.919	0.900	0.897	0.884	0.882	0.884	0.882	0.918	0.883	0.877	Y	Y	Y	Y	Y
NDISI	X12	0.805	0.716	0.535	0.668	0.062	0.060	0.085	0.102	0.686	0.058	0.894	0.035	Y	Y	N	N
Land use	X13	0.857	0.758	0.630	0.628	0.353	0.352	0.367	0.365	0.734	0.359	0.901	0.629	0.336	Y	Y	Y
Luminous data	X14	0.805	0.688	0.514	0.643	0.108	0.102	0.117	0.117	0.652	0.119	0.883	0.125	0.400	0.081	Y	N
GDP	X15	0.792	0.685	0.513	0.618	0.081	0.072	0.084	0.099	0.652	0.087	0.881	0.099	0.377	0.108	0.048	N
Population density	X16	0.791	0.693	0.513	0.616	0.089	0.072	0.094	0.102	0.660	0.102	0.882	0.098	0.374	0.109	0.069	0.050

Figure 9. Interactive detection matrix

Figure. 9 shows that compared with the explanatory power of a single factor, the effects of all probe factors on the spatial differentiation characteristics of RSEI in the study area are synergistically enhanced after interaction, and the effects of all influencing factors do not exist independently. From the perspective of the interactive explanatory power of the two detection factors, NDMI∩green degree (q=0.919),NDMI∩vegetation coverage (q=0.918),NDMI∩dry degree (q =0.909) and NDMI∩land use type (q =0.901) has the strongest explanatory power for the spatial differentiation characteristics of Saihanba RSEI. It is worth noting that in single factor detection (Table. 7), q value of greenness component is less than dryness component (0.6629<0.7795), while under the interaction with NDMI, the explanatory power of greenness component on SPATIAL differentiation characteristics of RESI is greater than dryness component (0.919>0.909). That is, greenness component shows stronger explanatory power under the interaction of NDMI. In addition, 22 pairs of interactive factors, such as NDISI∩soil erosion, slope∩DEM, GDP and population, are strongly correlated with each other, and the ecological detection value is N, indicating that the combination of these factors has no significant difference on the spatial differentiation characteristics of RSEI.

Combined with the explanatory ability and influence of each indicator, we can construct an indicator system, as shown in Figure. 10.

Figure 10. Ecological environment index system

4.3.3. Results

According to the above model results, we evaluated the ecological environment of all cities in China, compared the evaluation score with the score of Saihanba, and calculated the degree of similarity with the ecological environment before the restoration of Saihanba. The normalized results are shown in Figure. 11.

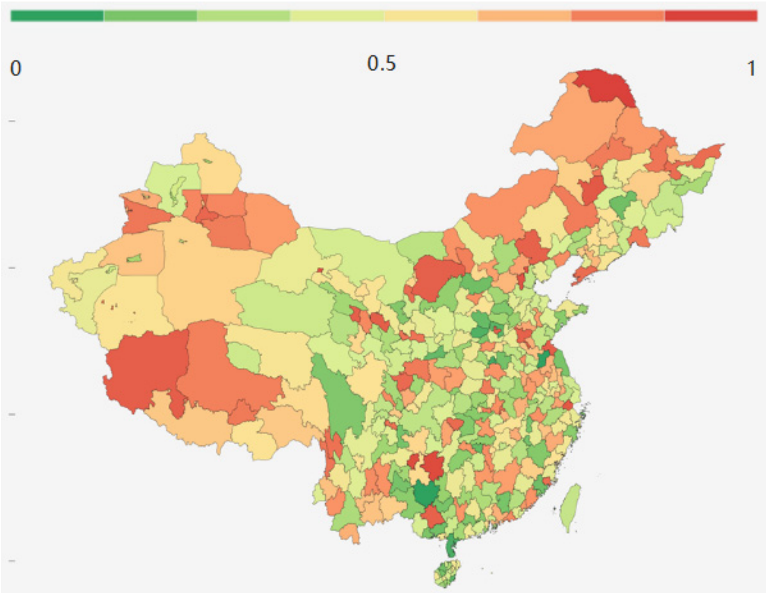

Figure 11. Evaluation map of cities in China

As can be seen from Figure. 11, the ecological status of most areas in western and northern China is similar to that before The restoration of Saihanba, that is, the ecological environment is relatively poor. Only a small part of the central, southern and eastern regions have similar ecological environment to Saihanba. Due to space limitations, we only list the top ten regions that can be promoted here: Greater Hinggan Mountains region, Qiandongnan Miao and Dong Autonomous Prefecture, Guiyang, Xining, Jiaxing, Jiamusi, Urumqi, Ali, Lanzhou and Jiayuguan. The similarity between them and saihanba's ecological environment before restoration is shown in Table. 9.

Table 9. Ranking of the top 10 regions in similarity

Region	Similarity	Rank	Region	Similarity	Rank
Greater Hinggan Mountains region	0.936	1	Jiamusi	0.762	6
Qiandongnan Miao and Dong Autonomous Prefecture	0.923	2	Urumqi	0.753	7
Guiyang city	0.891	3	Ali	0.724	8
Xining city	0.843	4	Lanzhou city	0.693	9
Jiaxing city	0.810	5	Jiayuguan city	0.685	10

If ecological zones are established in the geographical locations in Table. 9, the vegetation coverage, water resources and oxygen content there will become rich, and carbon dioxide absorption will be greatly improved. In addition, the ecological environment of these areas will be transformed from inferior to superior, achieving qualitative improvement. This is in line with China's goal of "carbon neutrality". When more plants are planted, the amount of carbon dioxide that can be absorbed also increases, thus neutralizing the carbon emissions caused by social activities and the carbon dioxide generated by commercial carbon sinks, thus facilitating the realization of the goal of producing as much carbon dioxide as absorbed. It can be said that the promotion of the Saihanba ecological model in these 10 regions will have a huge positive impact on China's goal of "carbon neutrality".

4.4. Planning and Evaluation Model of American Ecological Reserve

4.4.1. Problem Analysis

China's model of sihanba ecological protection has set an example for the asia-pacific region, in order to this pattern, we selected the United States as the research object, collecting relevant data, first of all, based on K - means cluster classification model in the United States, the United States area 51 state grade of clustering, the most crucial to construct ecological reserve, The quantity and scale of ecological protection areas to be built are determined by analyzing the corresponding prefectural areas. Then we collected the previous ecological protection data of the selected area and established an evaluation model for the greenhouse gas absorption and carbon emission efficiency of the ecological protection area based on DEA.

4.4.2. Selection and Planning Model of Regional Ecological Reserves in the United States based on K-Means Clustering

a. Model principle

K-means clustering is a clustering algorithm based on sample set division. K-means clustering divides the sample set into K subsets, forming K classes, and divides N samples into K classes. The distance between each sample and the center of the class to which it belongs is the minimum, that is, the samples in the same class have a high degree of similarity, while there is a large difference between different categories.

First of all, for a given central value ($m_1, m_2, \ldots, m_k$), Find A partition C, minimize the objective function:

$$\min_{C} \sum_{l=1}^{k} \sum_{C(i)=l} \left\| x_i - m_l \right\|^2$$

That is, when the class center is determined, each sample is divided into a class to minimize the total distance between the sample and the center of the class to which it belongs. Each sample is assigned to class G_l of its nearest center m_l.

Secondly, for a given partition C, find the center of each class: ($m_1, m_2, \ldots, m_k$), Minimize the objective function:

$$\min_{m_1 \cdots m_k} \sum_{l=1}^{k} \sum_{C(i)=l} \left\| x_i - m_l \right\|^2$$

Finally, for each class G_l containing n_l samples, Update the mean m_l:

$$m_l = \frac{1}{n_l} \sum_{C(i)=l} x_i, \quad l = 1,2,\cdots,k$$

b. Variable selection

Table 10. Specific indicators

Target layer	Criterion layer	Index layer	Data sources
Cluster analysis of ecological environment in American States	Pressure	CO_2 emissions	https://www.bea.gov/
		SO_2 emissions	
		NO_2 emissions	
	State	Vegetation coverage	https://www.fs.usda.gov/
		Afforestation area	
		PM2.5	https://www.epa.gov/
		Rainfull	https://www.bea.gov/
	Respond	Use of renewable resources	https://www.eia.gov/
		Use of new energy	

With reference to relevant literature and website data and comprehensive consideration of the selection of cluster variables, we select the following 9 variables to analyze the ecological environment of each state in the United States, as shown in Table. 10.

c. Determine the optimal number of clusters

In order to determine the optimal number of clustering, we use the elbow method to determine the optimal K value, whose basic idea is that the k value when the within-cluster sum of squared errors increases sharply is the optimal K value. In other words, k-means clustering is firstly carried out for different K values, curves of different K values are obtained according to the clustering deviation, and clustering deviation diagrams corresponding to different K values are drawn. Finally, k values corresponding to the sudden increase of clustering deviation or the most significant inflection point are found, where the clustering deviation SSE is defined as:

$$SSE = \sum_{i=1}^{N}\sum_{j=1}^{k} w_{(i,j)} = \left\| p_i - c_j \right\|_2^2$$

N is the number of samples; k is the number of clustering; p_i is the i sample point; C_j is the center of cluster j; if sample p_i is in cluster j, $w(i,j)=1$, Otherwise, $w(i,j)=0$.

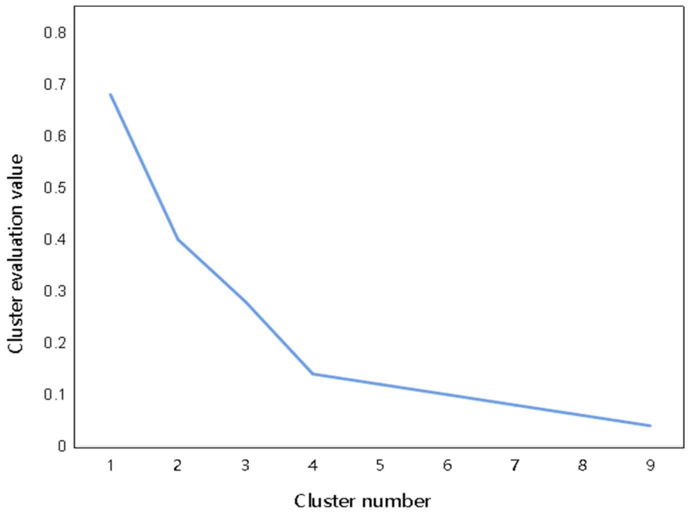

Figure 12. Cubit diagram of cluster number

We used Python to draw an elbow plot of the number of clusters. As shown in Figure. 12, a significant inflection point appeared when k=4, so the optimal number of clusters should be determined as 4.

d. Analysis of clustering results

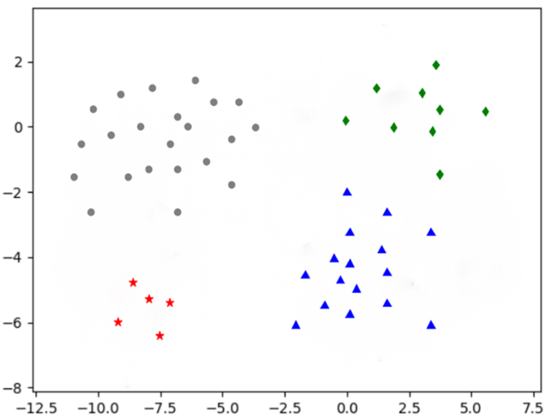

Figure 13. Clustering results

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As shown in Figure. 13, through K-means clustering, 51 STATES in the United States are divided into four categories according to their ecological environment status. Among them, Ohio, Indiana, West Virginia, New Jersey and Louisiana have the worst ecological environment assessment, as shown in Figure. 14. Ohio, Indiana, West Virginia, New Jersey and Louisiana are the states most in need of conservation.

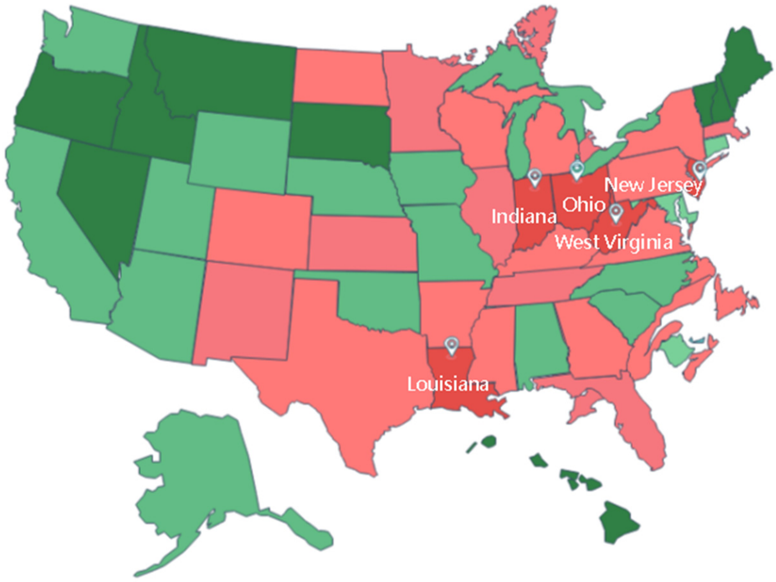

Figure 14. Cluster map

e. Determine the quantity and scale of ecological protection areas

Ohio: The state ranks first in industrial water consumption in the United States, and many industries depend on groundwater for supply. Manufacturing is the lifeblood of the state's economy and employs the most people, with machinery, automobiles and aircraft among the most important sectors. Rubber products, porcelain, electrical appliances, pumps, pipes and steam excavators accounted for the first in the United States output. Therefore, a large amount of industrial water use and deforestation have brought great pressure to Ohio's ecological environment. We analyzed the geomorphic characteristics and industrial environmental pollution of each city in Columbus, Cleveland, Cincinnati and Toledo, and determined that four cities should be set up as ecological reserves.

Indiana, the state capital, is in the middle of the moraine plain. The state has two characteristics: first, the moraine plain located in the central part of the state, the largest and complete. Second, the state has become the "crossroads" of the Midwest as it is the only way to and from the Midwest states. Therefore, the prosperous development of its transportation industry also leads to the destruction of a large number of its ecological environment. According to the analysis of the specific geomorphic characteristics of the cities under the state, We decided to set up ecological protection areas in Rush County, Shelby County, Steuben County, Switzerland County and Vermillion County.

West Virginia: Bituminous coal is rich in mineral resources in the state, which has brought rich economic benefits. However, excessive mining and the development of coal mining industry, as well as the destruction of a large number of mountain structures and the emission of industrial waste gas, have brought a huge impact on the ecological environment of the state. We analyzed the urban industrial development and ecological environment in Boone County, Berkeley County, Brooke County and Hardy County, and determined that ecological protection areas should be established in four cities.

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New Jersey: The state is located in the coastal area, so the shipping traffic drives the economic development of the state and attracts a large number of people to live in the state. As a result, the population density increases, and the high degree of urbanization brings a huge impact on the environmental carrying capacity of the state. According to the actual situation of the state, we analyzed the specific geomorphic characteristics of each city in the state, and determined that ecological protection areas should be set up in Elizabeth and Newark;

Louisiana: The state is rich in oil and other mineral resources, which bring a lot of positive sources to the state and promote the development of related industries. However, due to excessive mining of mineral resources and industrial wastewater discharge, the ecological environment level of the state has declined significantly. We analyzed the landscape and ecological characteristics of the cities in the state, we determined that Saint Bernard Parish, Santa Helena Parish, West Carroll Parish, Vermillion Parish, Pichland Parish, Lincoln Parish and Morehouse Parish has an ecological reserve in seven cities.

4.4.3. Evaluation Model of Greenhouse Gas Absorption and Carbon Emission Capacity of Ecological Reserve based on DEA

a. Efficiency measurement method and model principle

DEA (Data Envelopment Analysis) can effectively solve the efficiency measurement problem of multiple inputs and multiple outputs, and the greenhouse gas and carbon emission efficiency of ecological reserve will gradually reach the optimal state with the increase of the input scale, and the scale return is changing. Therefore, this paper chooses the BCC model assuming variable return to scale for calculation, and the specific model is as follows:

$$\min \theta - \varepsilon\left(\hat{e}^T S^- + e^T S^+\right)$$

$$s.t.\begin{cases} \sum_{j=1}^{n} X_j \lambda_j + S^- = \theta X_0 \\ \sum_{j=1}^{n} Y_j \lambda_j - S^+ = Y_0 \\ \lambda_j \geq 0, S^-, S^+ \geq 0 \end{cases}$$

Among them: $j = 1, 2, \cdots, n$, Presentation decision unit, X and Y represent input and output vectors; θ represents efficiency evaluation value; S^+ and S^- represents the slack variable of technology market input and output index; λ_j represents the weight of the JTH decision unit. If $\theta = 1, S^+ = S^- = 0$, then the DEA of decision unit is effective; if $\theta = 1, S^+ \neq S^- \neq 0$, then the weak DEA is effective; if $\theta < 1$, then decision making unit non-DEA is valid.

b. Index System Construction

Table 11. The indicator system

Primary index	Secondary indicators
Input index	Green coverage area
	Capital investment intensity
	Number of ecological protection areas
	Area of Ecological Reserve
Output indicators	Greenhouse gas emissions
	Carbon emissions

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According to relevant literature reference, we selected four indicators such as green coverage area and capital input intensity as input indicators of DEA model, and determined greenhouse gas emissions and carbon emissions as output indicators. The specific indicators are shown in Table. 11.

4.4.4. Results Analysis

We obtained the data of the last five years from relevant websites of each state and region, analyzed and predicted the data of the last two years based on relevant literature, and obtained the evaluation results through DEA model, as shown in Table. 12.

Table 12. Evaluation results of greenhouse gas absorption and carbon emission capacity of ecological reserves in five states of the United States

Year / State	2017	2018	2019	2020	2021	2022	2023
Ohio	0.573	0.561	0.578	0.603	0.624	0.673	0.703
Indiana	0.612	0.628	0.642	0.658	0.687	0.715	0.745
West Virginia	0.558	0.569	0.578	0.591	0.631	0.661	0.714
New Jersey	0.593	0.603	0.609	0.631	0.675	0.710	0.743
Louisiana	0.612	0.609	0.615	0.631	0.644	0.689	0.721

In Ohio, Indiana, West Virginia, New Jersey and Louisiana, greenhouse gas absorption and carbon emission capacity increased by 22.7%, 21.7%, 28.0%, 25.3% and 17.6%, respectively.

5. A Letter to the Organizing Committee of the APMCM

Dear APMCM Organizing Committee:

The earth is the common home of human beings. The topic C of this APMCM is about environmental protection. The great miracle of Saihanba area from desert to forest farm sets an example for the cause of environmental protection around the world. In view of this problem, our team established a variety of mathematical models and made a solution.

Firstly, for problem one, In order to make a comparative analysis of the environmental conditions before and after the restoration of Saihanba, we collected relevant data of Saihanba Forest Farm from 1962 to 2021, and took 1983 as the time point of division, namely 1962-1982 as the pre-restoration period and 1983-2021 as the post-restoration period. Nine data, including forest coverage rate (%), were used as analysis indicators. The rank sum ratio evaluation method was used to establish the evaluation model, and the comparison results were obtained. Secondly, for problem two, In order to evaluate the effect of Saihanba forest farm on resisting sandstorm in Beijing. From the influence, our traffic impact affects, electricity, communications, agriculture, animal husbandry and industrial seven aspects to choose disasters 28 indicators such as population, aircraft flight delays, build based on grey fuzzy comprehensive evaluation in Beijing against sand ability evaluation model, the role of quantitative evaluation of sihanba against dust storms in Beijing. Next, For problem three, we choose remote sensing ecological index model (RSEI) method, that is, through principal component analysis, coupled with four important ecological environmental impact factors (greenness, temperature, dryness and humidity) to analyze the ecological environment quality of Saihanba, and use the ecological model suitable for the restoration of Saihanba to consider the ecological conditions of other areas. Considering to promote implementation of the complexity of the situation around, on the basis of index of the first question, we joined the social factors and other resources, which select the terrain and soil factors, climate and vegetation factor, human activity factor and factor to build the model, model structure and the ecological construction in the city or not judgement. At last, For problem four, we selected the United States as the research object, collecting relevant data, first of all, based on K - means cluster classification model in the United States, the United States area 51 state grade of clustering, the most crucial to construct ecological reserve, The quantity and scale of ecological protection areas to be built are determined by analyzing the corresponding prefectural areas. Then we collected the previous ecological protection data of the selected area and established an evaluation model for the greenhouse gas absorption and carbon emission efficiency of the ecological protection area based on DEA.

For environment protection, we consider that everyone should attach great importance to the construction of nature reserves. We should further improve the understanding of the importance of the construction of nature reserves, earnestly practice the five development concepts, and strengthen the construction of nature reserves with a highly responsible political responsibility and a sense of historical mission. Besides, we should increase funding for protection and strengthen infrastructure construction. To ensure that the work of returning farmland to wet land is carried out in an all-round way, and to reduce the interference of human activities to the main protected objects; Accelerate the construction of infrastructure and capacity of the protected areas, complete the work of marking and demarcating on schedule, actively adopt modern technology, carry out monitoring and patrol; For the cadres and workers stationed in the control and protection station all the year round refer to the town and township workers included in the municipal finance to receive township subsidies within the scope, to ensure the smooth development of the work of the protected area.

We sincerely thank you for reading our letter and hope you will adopt our suggestions.

6. Evaluation of the Model

6.1. Strengths

6.1.1. Robustness and Flexibility

The fundamental strength of our model comes from its enormous flexibility, where none of the parameters in our model is fixed, even the structure of the network. And since that all the parameters are learned from data, our model is very easy to be customized, therefore could be applied widely. Our model also incorporates the idea of big data. That is to say , with more and more data(evidence), our model can give more and more precise predictions. Furthermore, our model has the notion of time, which is omitted in most mathematical models.

6.1.2. Easy to Understand

Adopting a hierarchical structure, our model can be easily understood with a single graph and several lines of explanation. Hence, our model is more likely to be understood by the decision and policy makers with the presence of their knowledge gap in the complex interconnected system.

6.1.3. Extensive Evaluation Index System

We constructed respectively based on the above problem sihanba ecological environment evaluation index system, sihanba forest farm of Beijing from sand ability evaluation index system of influence, China's ecological environment rating index system, evaluation index system of the urban ecological environment and ecological reserve greenhouse gas emissions and carbon absorption ability evaluation system.The evaluation system described above is objective and accurate based on the knowledge of geography and ecological environment.

6.2. Weaknesses

6.2.1. Potential Invalid Assumptions

Another obstacle that may hold back our models performance is that the assumptions made to simplify the model may be invalid, therefore leading to a less useful model.For example, in the model of greenhouse gas absorption and carbon emission capacity of ecological reserves, the indicators that may affect the results are not four, such as green coverage area, and there may also be social factors affecting the evaluation results.

6.2.2. Research Limitations

When determining the number and scale of ecological reserves in five states of the United States, due to the lack of specific data, it is not possible to collect a large number of index data and use mathematical theory to make accurate planning, so the number and scope of ecological reserves can only be determined according to the ecological environment status of cities in five states, which has certain limitations.

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